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NASA TECHNICAL MEMORANDUM

NASA TM X-73349

(NASA-TM-X-73349-VOL-1) SPACELAB EXPERIMENT COMPUTER STUDY. VOLUME 1: EXECUTIVE SUMMARY (PRESENTATION) (NASA) 68 P HC A04/MF A01 CSCL 2_8 N77-13097

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SPACELAB EXPERIMENT COMPUTER STUDY VOL 1: Executive Summary (Presentation)

By James L. Lewis, Bobby C. Hodges, and James O. Christy Data Systems Laboratory

April 1976

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NASA

George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama

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This is Volume I of five volumes.	
16. ABSTRACT	
The purpose of this study was to provide a quantitative cost	for various Spacelab flight
hardware configurations, along with varied software development	그 그 그 그 그 그 그 그 그 그 그 그 그 그 그 그 그 그 그
conclusions reached as a result of this study are as follows:	
 Spacelab program cost for software development and m experimental hardware and software options. 	amtenance is independent of
experimental nardware and software options.	化电影 建设施设施的特别建设的设备
2. Distributed standard computer concept simplifies softw	are integration without a
significant increase in cost.	
3. Decision on flight computer hardware configuration sho	그 그 그 그 그 그 그 그 그 그 그 그 그 그 그 그 그 그 그
selection for a given mission and a detailed analysis of the mission	n requirements are completed.
This report is published in five volumes: Volume I contain	s the Evecutive Summary
(Presentation); Volume II, Study Elements and Approach; Volume	
Volume IV, Spacelab User Cost Data (Central Experiment Comput	
User Cost Data (Distributed Computer).	
This is Volume I: Executive Summary (Presentation).	45 원전한 시대로 맞을 목숨하는 일을 됐
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	MARSHALL SPACE FLIGHT CENTER	NAME:	J. T. POWELL		
DATA SYSTEMS LABORATORY	SPACELAB EXPERIMENT COMPUTER STUDY	DATE	APRIL 1976		
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ORGANIZATION:

MARSHALL SPACE FLIGHT CENTER

SPACELAB EXPERIMENT COMPUTER STUDY

NAME:

J. T. POWELL

DATEL

APRIL 1976

OBJECTIVE OF STUDY

TO DEFINE, VIA ANALYSIS AND TRADE STUDIES, THE MOST COST EFFECTIVE CONFIGURATION OF FLIGHT COMPUTATIONAL RESOURCES THAT WILL SATISFY SPACELAB USER REQUIREMENTS

APPROACH

- PROJECT COSTS ASSOCIATED WITH VARIOUS OPTIONS (CENTRALIZED VS. DISTRIBUTED) THAT CAN POTENTIALLY BE ADOPTED TO SATISFY THESE REQUIREMENTS
- PROJECT TOTAL COSTS ASSOCIATED WITH SOFTWARE DEVELOPMENT INCLUDING:
 - EXPERIMENT COMPUTER(S) SOFTWARE
 - SUBSYSTEM COMPUTER SOFTWARE
 - EGSE COMPUTER SOFTWARE
 - SUPPORT SOFTWARE
 - SIMULATION SOFTWARE
 - ASSOCIATED HARDWARE

N

LABORATORY

MARSHALL SPACE FLIGHT CENTER

SPACELAB EXPERIMENT COMPUTER STUDY

NAME:		· :
1.	J. T. POWELL	
DATE:		

APRIL 1976

STUDY METHOD

- DERIVE COMPUTATION REQUIREMENTS FOR SPACELAB PAYLOAD ELEMENTS (EXPERIMENTS)
 BY DETAILED ANALYSIS OF THREE MISSIONS EXTRAPOLATION TO 226 MISSIONS IN MISSION MODEL
 - SPEED.
 - MEMORY MAIN AND BULK
 - STATEMENTS TO BE CODED
- ESTIMATE SIZE OF EUROPEAN DELIVERED SOFTWARE AND THE EXPECTED CHANGE RATE
- DEFINE OPTIONS TO BE EVALUATED
- DEVELOP COMPREHENSIVE SET OF ASSUMPTIONS AND GROUND RULES
- DEFINE METHOD OF COSTING FOR EACH ELEMENT
- COMBINE COSTS TO DETERMINE YEARLY AND TOTAL COSTS
- MAINTAIN SEPARATION OF COSTS SPACELAB AND USER
- EXAMINE MAJOR COST ELEMENTS FOR SENSITIVITY TO ASSUMPTIONS AND GROUND RULES
- MAINTAIN TRACEABILITY FOR ALL COST ELEMENTS

w

STUDY APPROACH

THE OVERALL APPROACH FOR SIZING EXPERIMENT APPLICATION SOFTWARE WAS TO REVIEW ALL PAYLOAD ELEMENTS CONTAINED IN THE SPACELAB MISSION MODEL (PMO1, 75-253, DATED 11/75) WHICH CONSISTS OF 226 FLIGHT OF FORTY-FIVE (45) DIFFERENT MISSIONS. OF THIS TOTAL NUMBER OF MISSIONS THREE (3) WERE SELECTED FOR DETAILED ANALYSIS. THE THREE (3) SELECTED WERE MISSIONS EIGHT (8), FOURTEEN (14), and TWENTY ONE (21). FOR THESE THREE (3) THE DETAILED SOFTWARE REQUIREMENTS WERE DERIVED AT THE PAYLOAD ELEMENT FUNCTIONAL LEVEL. THE DERIVED REQUIREMENTS WERE STATED IN TERMS OF MAIN MEMORY, BULK MEMORY, AND EQUIVALENT ADDS PER SECOND, TEMPERED BY REALISTIC GROUNDRULES APPLIED TO MINIMIZE THE TOTAL SOFTWARE JOB WHILE MAXIMIZING PAYLOAD RETURN. FOR DATA LISTED IN SPDA AS TBD, ENGINEERING ESTIMATES WERE USED. MISSION TIME LINES WERE APPLIED AND REQUIREMENTS WERE SUMMED, IF APPROPRIATE. FINALLY, THE DATA GENERATED WAS EXTRAPOLATED OVER THE MISSION MODEL AND YEARLY TOTALS GENERATED FOR SOFTWARE DEVELOPMENT, MAINTENANCE, AND DISTRIBUTION.

NOTE THAT THE THREE (3) MISSIONS ANALYZED IN DETAIL WERE MADE UP OF 20 PAYLOAD ELEMENTS, NEARLY HALF OF THE TOTAL (47). THE FINAL SOFTWARE REQUIREMENTS DATA IS REFLECTED IN GENERAL DYNAMICS (CONVAIR DIVISION) REPORT "SPACELAB PAYLOADS ACCOMMODATION STUDY," DATED MARCH 5, 1976, REPORT NO. CASD-NAS76-010. CONTRACT NAS8-29462.

DATA SYSTEMS LABORATORY COMPUTER STUDY PRESENTATION QUTLINE STUDY DEFINITION OBJECTIVE APPROACH METHOD SOFTWARE REQUIREMENTS DEVELOPMENT COSTING SUMMARY	FORTA CVETTME	MARSHALL SPACE FLIGHT CENTER SPACELAB EXPERIMENT	J. T. POWELL	
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물레드발레, 물론 범제 계속 레트, 문인 시계 설립은 백자 모임에 모든 이번 사람이 무리되는 이번 수 있는 것은 그리고 있다면 가는 점점 사람이 되는 것이다. 그는 그렇게 되는				

MSFC Form 3304 (Rev Ogioler 1972)

SOFTWARE REQUIREMENTS STUDY GROUNDRULES

- DATA BASE USED
 - JULY 1975 SPDA LEVEL A PAYLOAD DATA
 - FOR MISSION 8, THE LEVEL 1 CONSTRAINTS FOR FIRST SPACELAB FLIGHT AND SPACELAB FIRST FLIGHT GUIDELINES LEVEL II (BOTH DATED NOV. 1975)
 - SPACELAB MISSION MODEL (PM01) 75-253, DATED 11/75
- USE DETAILED ANALYSIS DATA (MISSIONS 8, 14, 21) TO REPLACE LEVEL A DATA FOR APP-ROPRIATE PAYLOAD ELEMENTS
- TALL POLES (DENTIFIED WILL BE FURTHER EVALUATED BY MSFC/GDC
- FUNCTIONS THAT CANNOT BE EFFICIENTLY HANDLED BY THE CREW MANUALLY SHALL BE CON-SIDERED FOR AUTOMATION
- ◆THE CREW SHOULD BE PROVIDED A LEVEL OF PAYLOAD CONTROL AND MONITORING THAT WILL YIELD HIGH CONFIDENCE OF PROPER EXPERIMENT OPERATION AND EXPERIMENT DATA QUALITY
- THROUGH MODEST INCREASES IN ON-BOARD PROCESSING, REAL-TIME TRANSMISSION REQUIREMENTS WILL BE MINIMIZED WHERE POSSIBLE
- PAYLOAD ELEMENT REQUIREMENTS WERE SUMMED FOR EACH MISSION IF POINTING REQUIREMENTS WERE COMPATIBLE

FILE NO.

PAYLOADS USED FOR DETAILED ANALYSIS

MISSION 8 WAS SELECTED AT THE SPECIFIC REQUEST OF THE SPACELAB PROGRAM MANAGER. IT IS ATYPICAL SINCE IT IS THE FIRST SPACELAB FLIGHT, AND INCLUDES THE LARGEST NUMBER OF PAYLOAD ELEMENTS.

MISSIONS 14 AND 21 WERE SELECTED BECAUSE THEY REPRESENT A REASONABLE SPREAD OF REQUIREMENTS (LOW TO HIGH) AND BECAUSE GOOD DETAIL WAS AVAILABLE FROM PRIOR ANALYSES. THESE MISSIONS WERE ALSO COVERED IN THE CRAS STUDIES.

MISSIONS EXCEEDING CDMS CAPACITY

THE FIRST 3 MISSIONS, SHOWN OPPOSITE, SLIGHTLY EXCEED THE AVAILABLE OPERATIONS PER SECOND CAPACITY OF THE CENTRAL EXPERIMENT COMPUTER, WHEN THE OPERATING SYSTEM AND CONTINGENCY ARE CONSIDERED. IT WAS CONCLUDED THAT THESE 3 MISSIONS COULD BE ACCOMMODATED BY MINOR REVISION OF THE REQUIREMENT OR BY USING THE CONTINGENCY RESERVED.

THE LAST 4 MISSIONS LISTED EXCEED THE CURRENT AND ANTICIPATED STATE OF THE ART, IN TERMS OF OPERATIONS PER SECOND. IT WAS ASSUMED THAT THE FUNCTION COULD BE ACCOMPLISHED BY SPECIAL PURPOSE HARDWARE, YET TO BE DEFINED, AND THE SOFTWARE REQUIREMENTS WERE TREATED AS VALID. NO COSTS WERE INCLUDED FOR THE SPECIAL PURPOSE HARDWARE.

THE ATM/SPACELAB MISSION IS NO LONGER BEING CONSIDERED.

ORGANIZATION:

EF208

DATA SYSTEMS LABORATORY

MARSHALL SPACE FLIGHT CENTER SPACELAB EXPERIMENT COMPUTER STUDY

IN	AM	E١	

J. T. POWELL

DATE:

APRIL 1976

20

SPACELAB MISSION PAYLOAD MODEL

NO. OF FLIGHTS CALENDAR YEAR

					79	60	81	2 2	83	84	. \$5	84	87	345	23
	AST-10A	200 MISSION 21					1	1							
	AST-10B	200 STELLAR ASTRONOMY		1					1						
٠	AST-10C	ZOD STELLAR ASTRONOMY									1				
	AST-10007X*	200 STELLAR ASTRONOMY (28.5 DEG ORBIT)								1					
	AST-10007Y	200 STELLAR ASTRONOMY (80 DEG ORBIT)									1				
	AST-10030X	200 STELLAR ASTRONOMY (28.5 DEG ORBIT)	·							7				1	
	AST-10030Y	209 STELLAR ASTRONOMY (90 DEG ORBIT)													. 1
	AST-10F	200 STELLAR ASTRONOMY			10.0							1			_ _
	AST-TOI	200 STELLAR ASTRONOMY	eg for the con-									1			
	AST-10J	200 STELLAR ASTRONOMY	distribution of										1		-
	AST-10K07	200 STELLAR ASTRONOMY		+								-	1		
	AST-10K30	200 STELLAR ASTRONOMY	1.												
	AST-10L	200 STELLAR ASTRONOMY	40000							1					
	AST-10M	200 STELLAR ASTRONOMY													1
	AST-11B	200 SOLAR PHYSICS						1	2	2		1			m
	AST-11C07	200 SOLAR PHYSICS	5										 -		
	AST-11C30	200 SOLAR PHYSICS				-						1			_
	AST-11D30	200 SOLAR PHYSICS				 							1		
	AST-11E07	200 SOLAR PHYSICS	4.								 			1	_
	AST-11E30	200 SOLAR PHYSICS				 						_		- - -	1
	LS-2A07	100 LIFE SCIENCES SHUTTLE LABORATORY (MOD 1)					2	2					 	<u> </u>	·
	LS-2A30	100 LIFE SCIENCES SHUTTLE LABORATORY IMOD 11		1.0					2	2	2	2	2	2	2
	MALT (A)	300 FIRST SPACELAB MISSION (MISSION 8)				1	1		 -	-	1		1		1 - 3
	MU-2 (10)	200 MULTI-USER (MISSION 10)				1		1	2	1	1	2	2	3	2
	NN/D 15	200 SPACE MANUFACTURING	e e transporting						<u> </u>	1 i	<u> </u>		1	1	
	NN/D 16A X	300 EARTH OBSERVATIONS (ESA 28.5 DEG ORBIT)		- 1		1	 	-		1				1	
٠	NN/D 15A Y	300 EARTH OBSERVATIONS (ESA 90 DEG ORBIT)					7, 44		1	 	1	1	1	1	1 7
	NN/D 16B	200 ASTRONOMY ESA								 ∸	1		1		7
	QA-1A (14) X	300 MULTIDISCIPLINE APPLICATIONS (MISSN 14-65 DEGI						<u> </u>	 -	-	 		- i -	 	
	0A-1A (14) Y	300 MULTIDISCIPLINE APPLICATIONS (MISSN 14-50 DEG)										1 :	<u> </u>		;
	OA-1B X	300 GPL 1 (55 DEG ORBIT)	, a constant			-			1	 -		-	 	 ; 	<u></u>
	DA-1B Y	300 GPL 1 (\$0 DEG ORBIT)				 		-	- '-		 		1		1
	PHY-EA + GO	200 HIGH ENERGY (X-RAY/GAMMA RAY & COSMIC RAY S	SIRVEVI.				 	 	1	1	<u> </u>	 	<u> </u>		
	PHY-68	200 HIGH INCLINATION COSMIC RAY SURVEY				 				 	 		 		
	PHY-6C + 60	200 HIGH ENERGY (X-RAY ANGULAR STRUCT, & GAMERA	DAV SILDV			 	ļ			-	 ,		 	-	
•	PHY-6E30	260 GANNA-RAY PHOTOMETRIC STUDIES		-			├─		<u> </u>	-	 '-	-	1		 - -
	PHY-7A	300 AMPS (28.5 DEG ORBIT)	110		7.7				 		 	1.		1	1
. :	PHY-7B	300 AMPS (56 DEG ORBIT)		14, 27		 	 -	_1_	1	 	1	1	 	1	1
	PHY-7C	300 AMPS (90 DEG ORBIT)					-		 -	1	-		1	 	 ,
	SP-1A	300 SPACE PROCESSING LAB-MANNED & AUTOMATED IS	46464 <u>5</u>	41840		 	 		⊢⊹	1	1 1	1	1	1	+ +
	SP-18	200 SPACE PROCESSING PIGGYBACK 1 (AUTO, FURNACE,		- LL - 5)				1	<u> </u>	1	1.		1		
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109 - MOOULE

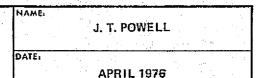
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APE-01	LIDAR/LASER SOUNDER	CN-04-S	ELECTROMAGNETIC ENVIRONMENT	AS-01-S	1.5 M IR TELESCOPE
AP-09-S	ELECTRON ACCELERO- METER	CN-08-S	TWT OPEN ENVELOPE	AS-04-S	1.0 M UV/OPTICAL TELESCOPE
AP-13-S	LOW LIGHT LEVEL TV	EO-20-S	IMAGING RADAR		
APE-07	PASSIVE ATMOSPHERE SOUNDER	OP-03-S	MICROWAVE RADIO-		
SPE-01 F	REE-FLOW ELECTROPH- ORESIS FACILITY	SP-31-S	METRY BIOLOGICAL/FURNACE		
SPE-80/ 85	ISOTHERMAL MULTI- HEATING FACILITY		SUBELEMENTS AND CO	nc	
EO-01-S	ZERO G CLOUD PHYSICS				
ST-31-S	DROP DYNAMICS FACILITY				
STE-10	ADVANCED HEAT PIPE				
LS-13-S	LIFE SCIENCE PAYLOAD				
ASE-01	WIDE-FIELD CAMERA				
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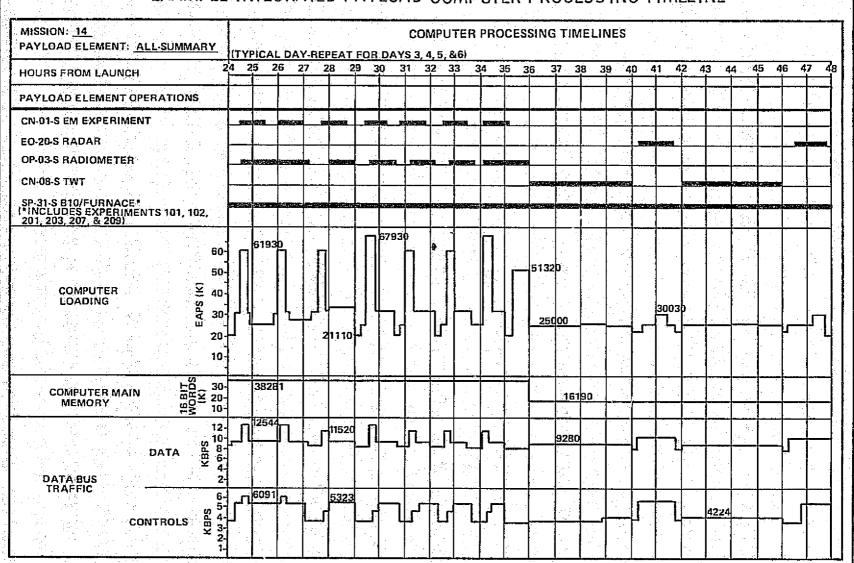
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SPACELAB EXPERIMENT COMPUTER STUDY

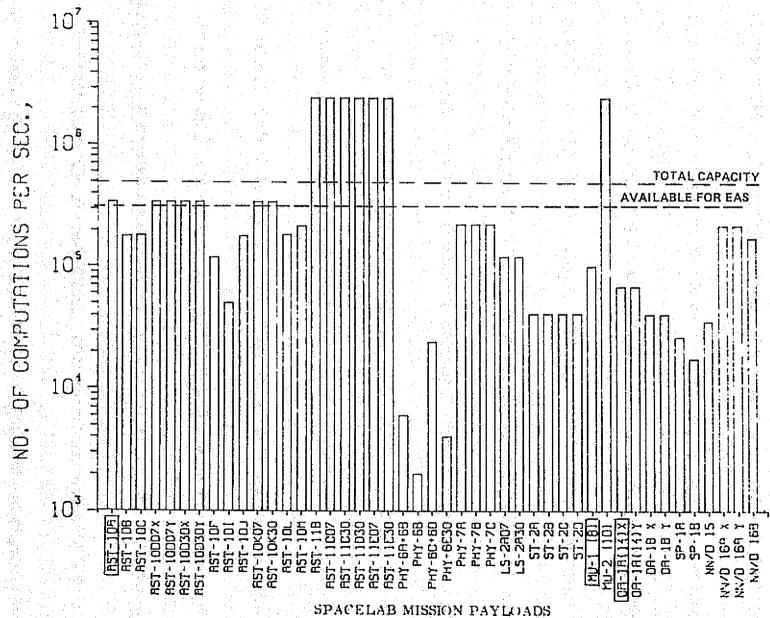


EXAMPLE INTEGRATED PAYLOAD COMPUTER PROCESSING TIMELINE



SPACELAB EXPERIMENT COMPUTER STUDY

NO. OF COMPUTATIONS PER SEC.



RAPID ACCESS MEMORY

THE AVAILABLE TOTAL RAPID ACCESS MEMORY CAPACITY, SHOWN OPPOSITE, IS THAT OF THE BASELINE SYSTEM. THE CAPACITY AVAILABLE FOR EXPERIMENT APPLICATION SOFTWARE IS LESS BECAUSE OF REQUIREMENTS FOR OPERATING SYSTEM, COMMON CENTRAL SERVICES, AND CONTINGENCY. ADDITIONAL MEMORY MODULES CAN BE ADDED WITH NO DESIGN CHANGE TO ACCOMMODATE THE INDICATED REQUIREMENTS. ESTIMATED COSTS FOR THIS WERE INCLUDED IN THE OVERALL COST ANALYSIS.

BULK MEMORY

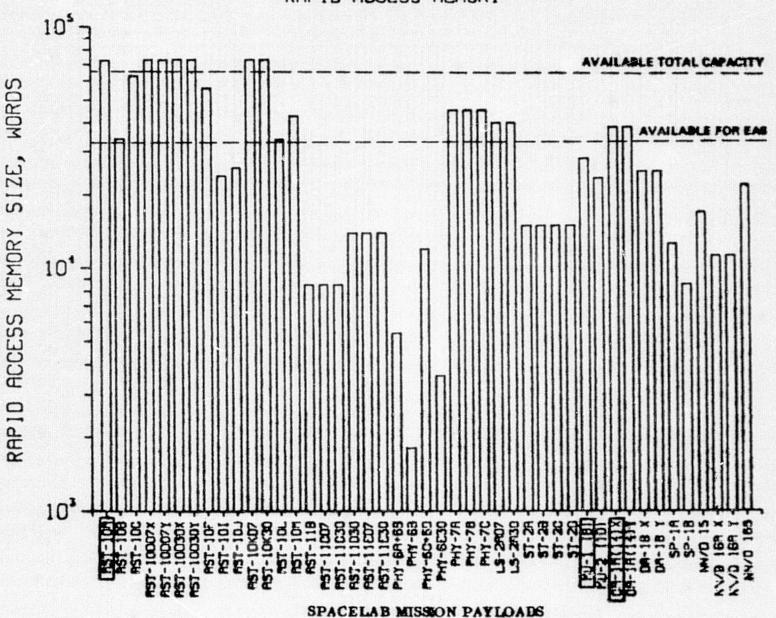
THE BULK MEMORY CAPACITY WAS EXCEEDED BY THE SAME 7 MISSIONS WHICH EXCEEDED THE COMPUTATIONS PER SECOND CAPACITY. NO COSTS WERE INCLUDED FOR MODIFICATION ON THE BASIS THAT THESE MISSIONS WOULD EITHER BE ELIMINATED, OR THE REQUIREMENT SOLVED BY THE SPECIAL-PURPOSE HARDWARE POSTULATED EARLIER.

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z,	ORGANIZATION:	Marie Tele	MARSHALL SPACE FLIGHT CENTER	- 1		NAME:		
					15.5	7	J. T. POWELL	
	DATA SYSTEMS		SPACELAB EXPERIMENT		11.			
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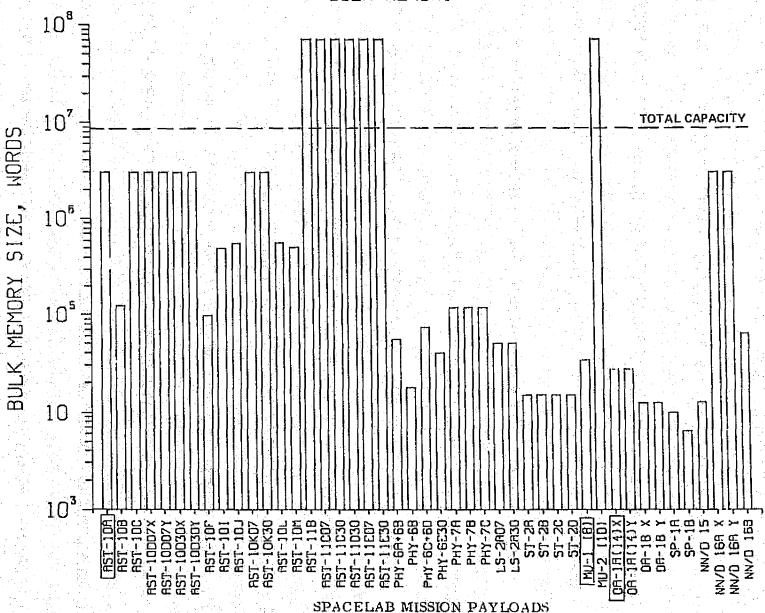
	MISSION P/L	P/L ELEMENTS	P/L ELEMENT COMPS/SEC	MISSION COMPS/SEC
1.	AST 10a	1M UV TELESCOPE 1M IR TELESCOPE	167,600 178,700	346,300
2.	AST 10d	1M UV TELESCOPE 3M AMBIENT TEMP. IR TELESCOPE	167,600 180,000	347,600
3.	AST 10k	1M UV TELESCOPE 2.5M IR TELESCOPE	167,600 180,000	347,600
4.	AST 11b/c	ATM SPACELAB	2,500,000*	2,500,000
5.	AST 11d	SOLAR ACTIVITY	2,500,000*	2,500,000
6.	AST 11e	SOLAR FINE POINTING	2,500,000*	2,500,000
7.	MU-2	X-RAY ANGULAR STRUCTURE	20,000	
		SOLAR ACTIVITY GROWTH MK. II INTERFEROMETER	2,500,000* 7,600	2,527,600

FILE NO.

RAPID ACCESS MEMORY







2

ORGANIZATION:

DATA SYSTEMS LABORATORY

SPACELAB EXPERIMENT
COMPUTER STUDY

J. T. POWELL

DATE:

APRIL 1976

ACCOMMODATION OF PAYLOAD REQUIREMENTS

- SPEED CENTRAL EXPERIMENT COMPUTER CAN ACCOMMODATE ALL MISSIONS EXCEPT 7
 - •THESE 7 HAVE STATED REQUIREMENTS THAT EXCEED STATE OF THE ART
 - MADE UP OF 4 PAYLOADS
- RAPID ACCESS MEMORY MUST BE EXPANDED FOR SOME PAYLOADS
 - •CAPABILITY INHERENT IN MACHINE NO REDESIGN
- BULK MEMORY CENTRAL MASS STORAGE CAN ACCOMMODATE ALL MISSIONS EXCEPT 7 (SAME 7 AS ABOVE)

5

COSTING APPROACH

THE COSTING APPROACH CONSISTED OF ESTABLISHING A COSTING METHOD FOR EACH COST FACTOR THAT WAS IDENTIFIED AS APPLICABLE TO THE COST ELEMENT WITHIN A GIVEN OPTION. THE COSTING METHOD EQUATION FOR EACH COST FACTOR WAS THEN APPLIED, YIELDING A RESULT IN TERMS OF: ONE TIME COST, COST PER FLIGHT, COST PER YEAR, USER COST, OR SPACELAB COST AS APPLICABLE. THIS DERIVED COST BY FACTORS WAS THEN SUMMED BY YEAR, ESCALATED, AND A TOTAL COST PER OPTION ESTABLISHED. THE TOTAL COST FOR EACH OPTION WAS THEN ANALYZED FOR SENSITIVITY TO THE COSTING RULES SUCH AS RATE OF CHANGE, COST PER STATEMENT, AND MISSION MODEL. DELTA TOTALS FOR EACH OPTION WERE DERIVED THUS GIVING VISIBILITY AS TO SENSITIVITY EFFECTS.

OPTIONS CONSIDERED

THE TWO BASIC OPTIONS CONSIDERED FOR THIS STUDY ARE: EMPHASIS ON USE OF CENTRAL ONBOARD COMPUTING RESOURCES WITH OVERFLOW TO MINI'S, AS REQUIRED, AND EMPHASIS ON USE OF DISTRIBUTED MINI'S WITH CENTRAL RESOURCES PROVIDING STANDARD SERVICES. SUB-OPTIONS WITHIN EACH OPTION CONSIDERED SUCH ITEMS AS STANDARD MINI'S, AND VARIOUS EXPERIMENT APPLICATION SOFTWARE DEVELOPMENT OPTIONS. IN ALL, THIRTY (30) OPTIONS WERE IDENTIFIED AND A PRELIMINARY ANALYSIS MADE OF EACH. NINE (9) OF THE THIRTY (30) WERE ELIMINATED FROM FURTHER DETAIL ANALYSIS DUE TO EXCESSIVE COSTS, OR DUE TO THEIR BEING TOTALLY IMPRACTICAL TO IMPLEMENT AS WELL AS CONTAINING EXCESSIVE COST ELEMENTS. THE REMAINING TWENTY-ONE (21) WERE ANALYZED IN DETAIL AND THE RESULTS ARE INCLUDED IN VOLUME 2, BOOK 2, APPENDIX BI THRU B30.

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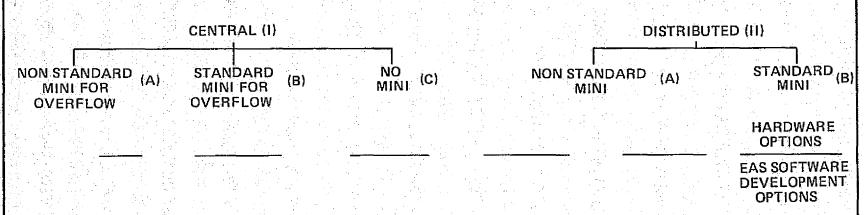
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ORGANIZATION: DATA SYSTEMS LABORATORY

MARSHALL SPACE FLIGHT CENTER SPACELAB EXPERIMENT COMPUTER STUDY

NAME	17	J. T. P	J. T. POWELL				
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	٠	APRIL	1976	•		7.17	

OPTIONS CONSIDERED



- 1. CENTRAL GROUP DEVELOPS EXPERIMENT APPLICATION SOFTWARE (EAS) AT CENTRAL SITE
- 2. PRINCIPAL INVESTIGATOR (PI) EXPERIMENT APPLICATION SOFTWARE (EAS) AT CENTRAL SITE
 - A. LOCAL TO CENTRAL SITE
 - B. UTILIZING REMOTE TERMINALS
- 3. PRINCIPAL INVESTIGATOR (PI) DEVELOPS EXPERIMENT APPLICATION SOFTWARE (EAS) ON HIS HOST THAT IS COMPATIBLE WITH CENTRAL SITE
 - A. ALL REALTIME SIMULATION AT CENTRAL SITE
 - B. REALTIME SIMULATION FOR DEDICATED EXPERIMENT PROCESSOR (DEP) EXPERIMENT APPLICATION SOFTWARE (EAS) ON REALTIME SIMULATION TEST SET (RTSTS) AT PRINCIPAL INVESTIGATOR (PI) FACILITY
- 4. PRINCIPAL INVESTIGATOR (PI) DEVELOPS EXPERIMENT APPLICATION SOFTWARE (EAS) ON HIS HOST THAT IS NOT COMPATIBLE WITH CENTRAL SITE.

CDMS

- HARDWARE MODIFICATIONS
- SUBSYSTEM COMPUTER SOFTWARE DEVELOPMENT AND ACCEPTANCE
- SUBSYSTEM COMPUTER SOFTWARE MAINTENANCE
- SUBSYSTEM COMPUTER: SOFTWARE CONFIGURATION MANAGEMENT, RELEASE. AND DISTRIBUTION
- EXPERIMENT COMPUTER: SOFTWARE DEVELOPMENT AND ACCEPTANCE
- EXPERIMENT COMPUTER. SOFTWARE MAINTENANCE
- EXPERIMENT COMPUTER SOFTWARE CONFIGURATION MANAGEMENT, RELEASE. AND DISTRIBUTIONS

EGSE

- HARDWARE MODIFICATIONS
- GROUND CHECKOUT SOFTWARE DEVELOPMENT AND ACCEPTANCE
- GROUND CHECKOUT SOFTWARE MAINTENANCE
- GROUND CHECKOUT SOFTWARE CONFIGURATION MANAGEMENT RELEASE, AND DISTRIBUTION
- EGSE COMPUTER SOFTWARE PRODUCTION SET DEVELOPMENT AND ACCEPTANCE
- EGSE COMPUTER SOFTWARE PRODUCTION SET MAINTENANCE
- EGSE COMPUTER SOFTWARE PRODUCTION SET CONFIGURATION MANAGEMENT, RELEASE, AND DISTRIBUTION

CENTRAL SITE

- FACILITY ACQUISITION.
- FACILITY OPERATION AND AND MAINTENANCE
- HOST AND SIMULATION COMPUTER SUPPORT SOFTWARE DEVELOPMENT AND ACCEPTANCE
- HOST AND SIMULATION COMPUTER SUPPORT SOFTWARE MAINTENANCE

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EF199 ORGANIZATION: MARSHALL SPACE FLIGHT CENTER NAME: J. T. POWELL SPACELAB EXPERIMENT **DATA SYSTEMS** LABORATORY DATE **COMPUTER STUDY APRIL 1976 USER COST ELEMENTS** PI HOST COMPUTER EXPERIMENT DEP* RTSTS* HOST AND EAS DEVELOPMENT EXPERIMENT PROCESSOR RTSTS ACQUISITION SIMULATION ACQUISITION COMPUTER EAS MAINTENANCE RTSTS MAINTENANCE. SUPPORT EXPERIMENT PROCESSOR OPERATION, AND SOFTWARE EAS INTEGRATION MAINTENANCE AND DISTRIBUTION MAINTENANCE DISTRIBUTION EXPERIMENT PREFLIGHT RTSTS SUPPORT CHECKOUT SOFTWARE DEP SOFTWARE DEVELOP-SOFTWARE DEVELOPMENT DEVELOPMENT MENT AND PROCUREMENT AND PROCUREMENT EXPERIMENT PREFLIGHT DEP SOFTWARE RTSTS SUPPORT CHECKOUT SOFTWARE MAINTENANCE AND SOFTWARE MAINTENANCE MAINTENANCE DISTRIBUTION AND DISTRIBUTION EAS DEPENDENT CENTRAL SITE HARDWARE SUPPLEMENT EAS DEPENDENT CENTRAL SITE SOFTWARE SUPPLEMENT EXPERIMENT REAL-TIME *DEP - DISTRIBUTED EXPERIMENT PROCESSOR SIMULATION SOFTWARE RTSTS - REAL-TIME SIMULATION TEST SET DEVELOPMENT EXPERIMENT REAL-TIME SIMULATION SOFTWARE MAINTENANCE

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 ORGANIZATION	- · · · · · ·	MARSHALL SPACE FLIGHT CENTER		NAME:	LT DOME!	
DATA SYSTEMS		SPACELAB EXPERIMENT			J. T. POWELL	
LABORATORY		COMPUTER STUDY		DATE:	APRIL 1976	
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MAJOR COSTING RULES

• EXPERIMENT APPLICATION SOFTWARE CHANGE RATE:

40% FIRST REFLY
30% SECOND REFLY
20% THIRD REFLY
10% EACH SUCCEEDING REFLY

• EGSE SOFTWARE CHANGE RATE:

5% EACH NEW FLIGHT 1% EACH REFLIGHT

SUBSYSTEM COMPUTER SOFTWARE CHANGE RATE:

OLUDEMENTS ANALYSIS

5% PER FLIGHT FOR 1ST THREE YEARS 10% PER YEAR THEREAFTER

- ALL COSTS ESCALATED 7% PER YEAR, COMPOUNDED ANNUALLY
- COST PER HIGHER ORDER LANGUAGE STATEMENT FOR EAS:

DESIGN, CODE. VERIFICATION	\$ 30.00
되는 옷 그렇게 됐지? 그는 그리를 받는데 보이는 그 때문에 되는 것이다.	\$ 45.00
• COST PER STATEMENT FOR INTEGRATION AND VERIFICATION IF IN CENTRAL COMPUTER (NOT APPLICABLE TO EAS IN DISTRIBUTED COMPUTER OPTIONS)	\$ 15.00
COST PER CHECKOUT STATEMENT	\$ 30.00
• COST PER ASSEMBLY LANGUAGE INSTRUCTION	\$100.00

- ONE HIGHER ORDER LANGUAGE STATEMENT, WHEN COMPILED, RESULTS IN FIVE COMPUTER INSTRUCTIONS
- ONE MAN-YEAR OF EFFORT IS EQUIVALENT TO \$50,000 IN 1976

SPACELAB AND USER COST

THE TOTAL SPACELAB AND USER COSTS ARE SHOWN TO INDICATE DELTA COSTS BETWEEN OPTIONS. OPTION IIA4 IS SHOWN FOR COMPARISON AND IS AN INDICATOR OF THE HIGH COSTS ASSOCIATED WITH OPTIONS IA4, IB4, IC3B, IC4, IIA1, IIA2A, IIA2B, IIA3A, AND IIA3B WHICH ARE NOT INCLUDED.

ORGANIZATION:

DATA SYSTEMS

LABORATORY

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SPACELAB EXPERIMENT COMPUTER STUDY

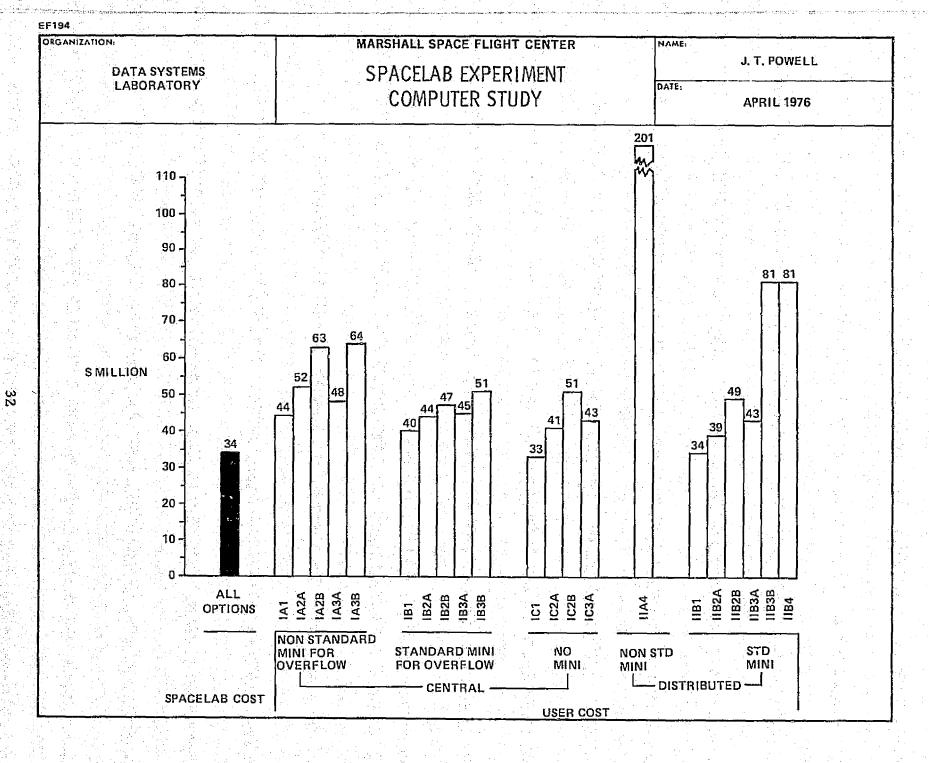
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	**	J. T. POWELL

DATE:

APRIL 1976

STATEMENTS TO BE CODED OPTION 11B2A

COST ELEMENT	FY77	78	79	80	81	02.	83	84	85	86	87	86	89	90	² 91
EAS DEVELOPMENT	1	1	-	4940	14596	8282	1240	3937	0	5183	4525	864	1550	-	•
EAS MAINTENANCE		-	-	-	3371	4443	7956	5344	7793	3969	5750	5618	5892	7877	7229
PREFLIGHT CHECKOUT SAW DEV	1	-	-	13020	4550	13950	3720	1860	0	2790	2790	930	930		
PREFLIGHT CHECKOUT S W MAINT		_	-	-	1302	558	2232	2511	4092	2790	4650	3627	4929	5022	5952
EXP. REAL TIME SIMULATION S/W DEV	•		-	19600	7000	21000	5600	2800	0	4200	4200	1400	1400	-	-
EXP REAL TIME SIMULATION SAW MAINT		:		-	1960	840	3360	37 ÉO	6160	4200	7000	5460	7420	7560	8950
DEP OP SYS DEV	-	-	-	800		•	-	-	_	-		-	:	_	•
DEP OP SYS MAINT	•	•	-	-	40	40	40	. 40	40	40	40	49	40	40	40
									-			: .			
STATEMENTS TOTAL	_	- ,	_	38360	32919	49113	24148	20272	18085	23172	28956	17945	-22161	20499	22181



SENSITIVITY TO COST PER STATEMENT

AN ANALYSIS OF SENSITIVITY TO COST PER STATEMENT WAS EXERCISED FOR EACH OPTION USING, AS A BASE, 50% OF THE ORIGINAL ESTIMATED COST PER INSTRUCTION OR LANGUAGE STATEMENT AS APPLICABLE. THE RESULTING DELTA COSTS FOR COMPARABLE USER OPTIONS AS WELL AS SPACELAB DELTA COSTS ARE SHOWN. DELTA COSTS FOR ALL OPTIONS DUE TO COST PER STATEMENT SENSITIVITY ARE INCLUDED IN VOLUME 1, EXECUTIVE SUMMARY.

ALSO SHOWN, ON OPTION IIA4, IS THE EFFECT OF PARTIAL STANDARDIZATION OF MINICOMPUTERS; i.e., EACH OF 12 DISCIPLINES WOULD USE THE SAME TYPE OF COMPUTER.

DATA SYSTEMS LABORATORY SPACELAB EXPERIMENT
COMPUTER STUDY

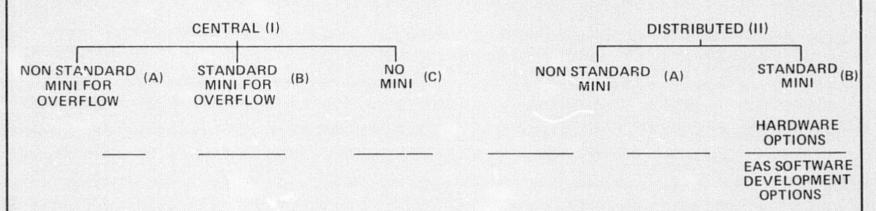
J. T. POWELL

DATE:

NAME:

APRIL 1976

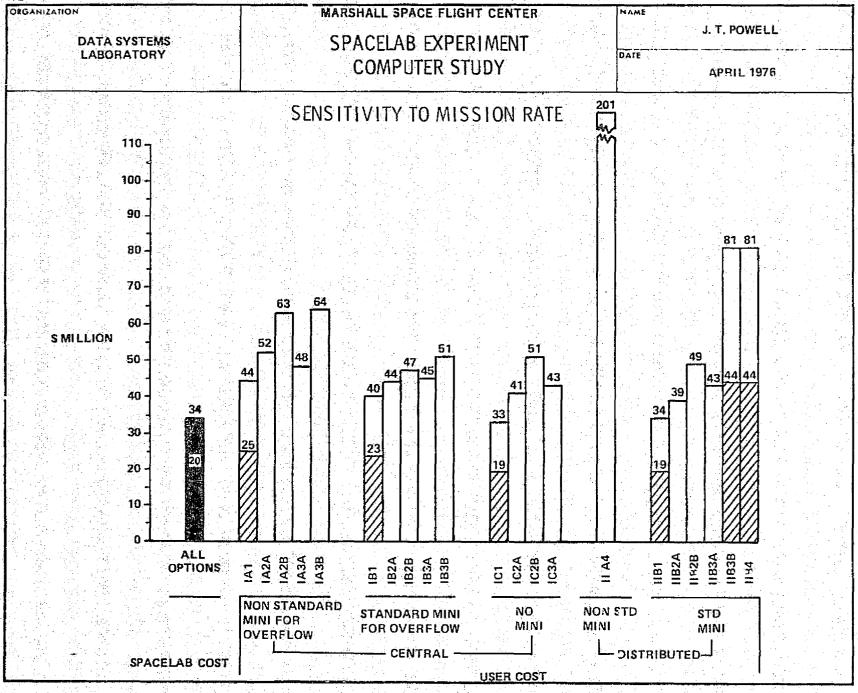
OPTIONS CONSIDERED



- 1. CENTRAL GROUP DEVELOPS EXPERIMENT APPLICATION SOFTWARE (E.AS) AT CENTRAL SITE
- 2. PRINCIPAL INVESTIGATOR (PI) EXPERIMENT APPLICATION SOFTWARE (EAS) AT CENTRAL SITE
 - A. LOCAL TO CENTRAL SITE
 - B. UT'LIZING REMOTE TERMINALS
- 3. PRINCIPAL INVESTIGATOR (PI) DEVELOPS EXPERIMENT APPLICATION SOFTWARE (EAS) ON HIS HOST THAT IS COMPATIBLE WITH CENTRAL SITE
 - A. ALL REALTIME SIMULATION AT CENTRAL SITE
 - B. REALTIME SIMULATION FOR DEDICATED EXPERIMENT PROCESSOR (DEP) EXPERIMENT APPLICATION SOFTWARE (EAS) ON REALTIME SIMULATION TEST SET (RTSTS) AT PRINCIPAL INVESTIGATOR (PI) FACILITY
- 4. PRINCIPAL INVESTIGATOR (PI) DEVELOPS EXPERIMENT APPLICATION SOFTWARE (EAS) ON HIS HOST THAT IS NOT COMPATIBLE WITH CENTRAL SITE.

SENSITIVITY TO MISSION RATE

IN ORDER TO INDICATE THE SENSITIVITY TO MISSION RATE AN EXERCISE WAS CONDUCTED USING A TWELVE (12) YEAR MISSION MODEL CONSISTING OF SEVENTY-SEVEN (77) TOTAL FLIGHTS. DELTA COSTS FOR THIS REDUCED MISSION MODEL ARE SHOWN FOR SPACELAB COST AND USER COSTS FOR SIX (6) COMPARABLE OPTIONS.



ORGANIZATION

DATA SYSTEMS LABORATORY

SPACELAB EXPERIMENT COMPUTER STUDY

lE:

J. T. POWELL

DATE:

APRIL 1976

SUMMARY

- SPACELAB SOFTWARE DEVELOPMENT AND MAINTENANCE COST IS INDEPENDENT OF OPTIONS
- COST IS NOT A SIGNIFICANT DRIVER BETWEEN CENTRAL AND DISTRIBUTED COMPUTER
 CONFIGURATIONS
- DISTRIBUTED COMPUTER CONCEPT SIMPLIFIES INTEGRATION WITHOUT SIGNIFICANT COST INCREASE
- STANDARD MINI HAS COST ADVANTAGES WHEN DEDICATED EXPERIMENT PROCESSOR
 IS SELECTED
- CENTRALIZED EXPERIMENT APPLICATION SOFTWARE DEVELOPMENT IS LEAST COST FOR ALL HARDWARE CONFIGURATIONS
- DECISION ON CENTRAL OR DEDICATED EXPERIMENT PROCESSOR SHOULD BE BASED ON ANALYSIS OF EACH MISSION REQUIREMENTS AFTER FINAL PAYLOAD SELECTION

ORGANIZATION.

DATA SYSTEMS

MARSHALL SPACE FLIGHT CENTER

SPACELAB EXPERIMENT COMPUTER STUDY

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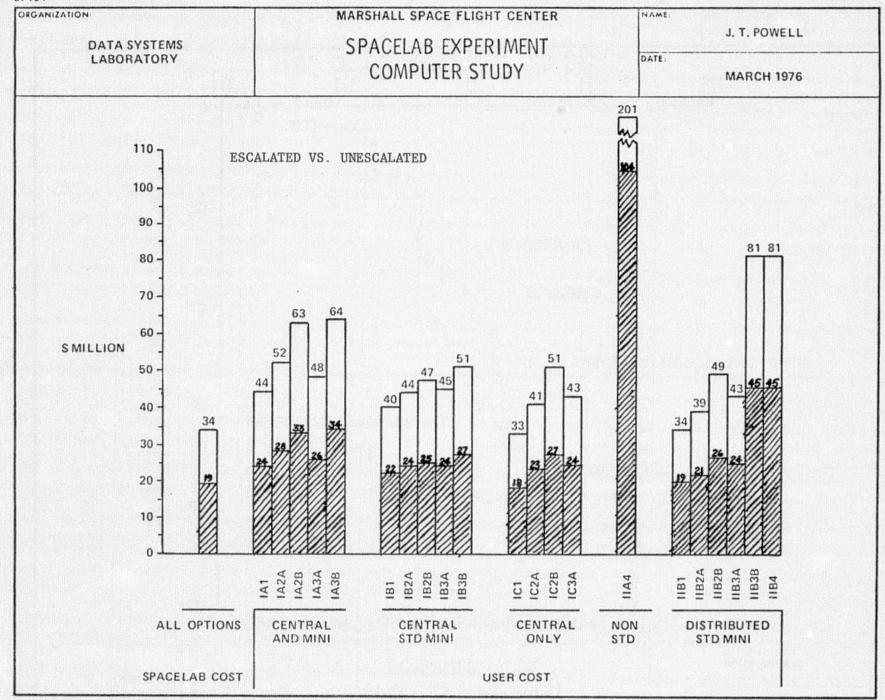
J. T. POWELL

DATE

MARCH 1976

ASSUMED CDMS FUNCTIONAL CAPABILITIES

- CRT HAS REFRESH CAPABILITY
- SYSTEM SOFTWARE ACCEPTS & ACCUMULATES CONTROL DATA VIA KEYBOARD ENTRY
- SPACELAB PROVIDES CAPABILITY TO INITIATE AND SCHEDULE P/L APPLICATION SOFTWARE AT DISCRETE MISSION ELAPSED TIMES
- SPACELAB PROVIDES TRANSFER OF TIME AND STATE VECTORS FROM ORBITER TO EXPERIMENT COMPUTER
- P/L APPLICATION SOFTWARE NOT REQUIRED TO SCHEDULE AND CONTROL SPACELAB MAGNETIC RECORDERS
- SPACELAB PROVIDES TRANSFER OF UPLINK COMMANDS FROM ORBITER TO EXPERIMENT COMPUTER
- SPACELAB PROVIDES FOR INPUT OF HIGH RATE P/L DATA TO EXPERIMENT COMPUTER
- SPACELAB TRANSFERS IPS STATE VECTORS FROM SPACELAB SUBSYSTEM COMPUTER TO EXPERIMENT COMPUTER
- ALL APPLICATION PROGRAMS, DATA CONSTANTS AND DISPLAY FORMATS STORED IN BULK MEMORY
- ALL APPLICATION PROGRAMS DATA CONSTANTS, DISPLAY FORMATS AND BUFFER DATA
 MEMORY FOR ACTIVE PROGRAMS ARE INCLUDED IN THE ESTIMATE OF RAPID ACCESS MEMORY



RAPID ACCESS MEMORY SIZE, WORDS

RGANIZATION		MARSHALL S	PACE FLIGHT CEN	TER	NAME		
DATA SYSTEMS LABORATORY		the state of the s	LAB EXPERIM MPUTER STUD		J DATE:	T. POWELL ARCH 1976	
						anon 1010	

REAL TIME SIMULATION TEST SET (RTSTS)

REQUIRED FOR USE BY PIS DEVELOPING DEP SOFTWARE

- O PERFORMS REAL TIME EXPERIMENT SIMULATIONS
- O PERFORMS REAL TIME CDMS SIMULATIONS

CENTRAL STANDARD SERVICES

DISPLAY

MASS STORAGE

o SERVES AS HOST COMPUTER FOR:

ASSEMBLY

COMPILATION

LINK EDIT

POST PROCESSING OF REAL TIME SIMULATIONS

SPACELAB EXPERIMENT COMPUTER STUDY

SELECTION OF MISSIONS FOR DETAILED ANALYSIS EARLY SHUTTLE MISSION CANDIDATES

MISSION NO.	8	10	12	14	19	21	26
CRITERIA FOR SELECTION	JOINT NASA/ESA	MULTI- DISCIPLINE	LIFE SCIENCES	MULTI- DISCIPLINE APPLIC.	AMPS	COMBINED ASTRONOMY	LIFE SCIENCES
Preliminary Mission Feasibility Established	MSFC Study	IMAP	IMAP DRM (PH A)	IMAP DRM	IMAP DRM	(DRM) ERNO Acom Analysis	(IMAP) (DRM) (PH A)
Anticipated Level of Computer Processing Requirements	Medium	Medium	Low	Low	High	High	Low
Availability of Existing or Near Term Supporting Data	Available - GDC Data Mgt. Study	Near Term - GDC Data Mgt. Study	Derivable from GDC Ph. A Study	Near Term -GDC Data Mgt. Study		Near Term -GDC Data Mgt. Study	Derivable from GDC Ph.A Study
Other Computer Processing Studies	-	CRASS	CRASS	CRASS	CRASS	CRASS	CRASS
Other Considerations	Close MSFC I/F	Payload Complement Expected to Change Soon	-	GDC Wrote DRM, Reviewed IMAP	Extremely Complex, Current Ph. B for Redefinition	at GDC	-

Selected for detailed analysis

) Study has close relation to mission

• CONTROL MONITO" • FOR C/O/VERIFICATION

. SIMULATION PROGRAMS

• SIMULATION PARAMETERS

SIMULATION MINI

• LOGGING

HOST

SCIENCE DATA

HI RATE

MUX

49

SIGNAL

PROCESSOR

EXPERI-MENT

DATA SYSTEMS LABORATORY

MARSHALL SPACE FLIGHT CENTER SPACELAB EXPERIMENT **COMPUTER STUDY**

NAME:

J. T. POWELL

DATE

APRIL 1976

CENTRAL EXPERIMENT COMPUTER FUNCTIONS

- NEEDED EVEN IF DISTRIBUTED COMPUTER CONFIGURATION IS ADOPTED
- EXECUTES STANDARD TASKS THAT ARE REQUIRED BY ALL PAYLOADS
- **⇒** EXAMPLES ARE
 - DISPLAY
 - KEYBOARD
 - ORBITER COMMUNICATION
 - DISTRIBUTION OF UPLINK COMMANDS
 - PCM FORMATTING

SPACELAB EXPERIMENT
COMPUTER STUDY

J. T. POWELL

DATE:

NAME:

APRIL 1976

OPTIONS NOT COSTED

- 1A4 IMPRACTICAL TO DEVELOP SUPPORT SOFTWARE FOR CENTRAL COMPUTER TO 1B4 RUN ON EACH NON STANDARD HOST 1C4
- 1C3B NO DEDICATED EXPERIMENT PROCESSOR (DEP) IN THIS OPTION THEREFORE NO DEP SOFTWARE SIMULATION REQUIRED
- IMPRACTICAL FOR CENTRAL SITE TO MAINTAIN SUPPORT FACILITIES FOR EVERY NON STANDARD DEP
- IIA3A IMPRACTICAL FOR CENTRAL SITE TO FURNISH SIMULATION FACILITIES FOR EVERY NON STANDARD DEP
- ◆ IIA3B COST IS THE SAME AS OPTION IIA4

\$3,180/Yr.

Checkout

Terminal Maintenance

SPACELAR EXPERIMENT COMPUTER STUDY

CENTRAL SITE FACILITY

360/65 AND PERIPHERALS		\$2,460 K	
SIMULATION COMPUTER		137 K	# *
		el	
COMPUTER INTERFACE DEVICE (CID)		186 K	
COMMAND AND DATA MANAGEMENT SYST	PEM (CDMS)	1,920 K	1
		\$4,703 K	
	*		
OPERATIONS AND MAINTENANCE		511 K	PER YEAR
		(\$245	PER HOUR)

SPACELAB All Options 153 EAS IA1 196 IA2A 230 IA2B 273 IA3A 214 IA3B 301 IB1 178 IB2A 191 IB2B 204 IB3A 200 IB3B 238 IC1 147 IC2A 182 IC2B 225 IC3A 177 IIA4 891 IIB1 150 IIB2A 176 IIB2A 176 IIB2B 217 IIB3A 190 IIB3B 414 IIB3B 414		and the second second	Escalated Average Cost/Flight (\$K)
IA2A 230 IA2B 273 IA3A 214 IA3B 301 IB1 178 IB2A 191 IB2B 204 IB3A 200 IB3B 238 IC1 147 IC2A 182 IC2B 225 IC3A 177 IIA4 891 IIB1 150 IIB2A 176 IIB2B 217 IIB2B 217 IIB3A 190 IIB3B 414	SPACELAB	All Options	153
IA2A 230 IA2B 273 IA3A 214 IA3B 301 IB1 178 IB2A 191 IB2B 204 IB3A 200 IB3B 238 IC1 147 IC2A 182 IC2B 225 IC3A 177 IIA4 891 IIB1 150 IIB2B 217 IIB2B 217 IIB3A 190 IIB3B 190 IIB3B 414	EAS	IA1	196
IA3A 214 IA3B 301 IB1 178 IB2A 191 IB2B 204 IB3A 200 IB3B 238 IC1 147 IC2A 182 IC2B 225 IC3A 177 IIA4 891 IIB1 150 IIB2A 176 IIB2B 217 IIB3A 190 IIB3B 414		IA2A	
IA3B 301 IB1 178 IB2A 191 IB2B 204 IB3A 200 IB3B 238 IC1 147 IC2A 182 IC2B 225 IC3A 177 IIA4 891 IIB1 150 IIB2A 176 IIB2B 217 IIB3A 190 IIB3B 414			273
IB1 178 IB2A 191 IB3B 204 IB3A 200 IB3B 238 IC1 147 IC2A 182 IC2B 225 IC3A 177 IIA4 891 IIB1 150 IIB2A 176 IIB2B 217 IIB3A 190 IIB3B 414			214
IB2A 191 IB2B 204 IB3A 200 IB3B 238 IC1 147 IC2A 182 IC2B 225 IC3A 177 IIA4 891 IIB1 150 IIB2A 176 IIB2B 217 IIB2B 217 IIB3A 190 IIB3B 414		IA3B	301
IB2B 204 IB3A 200 IB3B 238 IC1 147 IC2A 182 IC2B 225 IC3A 177 IIA4 891 IIB1 150 IIB2A 176 IIB2B 217 IIB3A 190 IIB3B 414			178
IB3A 200 IB3B 238 IC1 147 IC2A 182 IC2B 225 IC3A 177 IIA4 891 IIB1 150 IIB2A 176 IIB2B 217 IIB3A 190 IIB3B 414			
IB3B 238 IC1 147 IC2A 182 IC2B 225 IC3A 177 IIA4 891 IIB1 150 IIB2A 176 IIB2B 217 IIB3A 190 IIB3B 414			
IC1 147 IC2A 182 IC2B 225 IC3A 177 IIA4 891 IIB1 150 IIB2A 176 IIB2B 217 IIB3A 190 IIB3B 414			
IC2A IC2B IC2B IC3A I77 IIA4 IIB1 IIB1 IIB2A IIB2B IIB2B IIB3A I190 IIB3B I1B3B		IB3B	238
IC2A IC2B IC2B IC3A I77 IIA4 891 IIB1 IIB1 IIB2A IIB2B IIB2B IIB3A IIB3A IIB3B 414			- A
IC2B			
IC3A 177 IIA4 891 IIB1 150 IIB2A 176 IIB2B 217 IIB3A 190 IIB3B 414		·	
IIA4 891 IIB1 150 IIB2A 176 IIB2B 217 IIB3A 190 IIB3B 414			
IIB1 150 IIB2A 176 IIB2B 217 IIB3A 190 IIB3B 414		ICJA	117
IIB1 150 IIB2A 176 IIB2B 217 IIB3A 190 IIB3B 414		TT A 4	201
IIB2A 176 IIB2B 217 IIB3A 190 IIB3B 414			
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APPROVAL

SPACELAB EXPERIMENT COMPUTER STUDY Volume 1: Executive Summary

By James L. Lewis, Bobby C. Hodges, and James O. Christy

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

J. TO POWELL

Director, Data Systems Laboratory